





JTWC Technical Services NOAA Microwave Sounder Workshop July 2021



Why Are We Here?



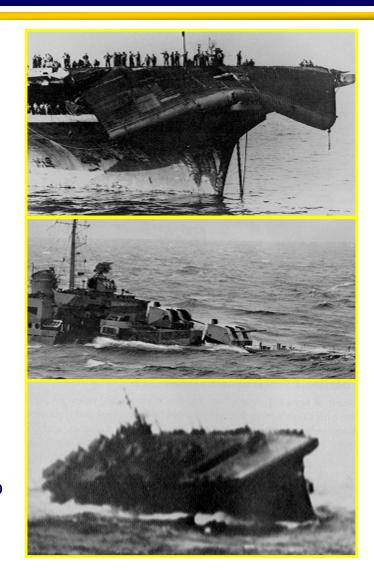


17 Dec 1944:

- Typhoon Cobra struck near the end of WWII
- Navy conducted air raids against Japanese airfields in the Philippine Sea
- 120kt winds, high seas and torrential rain
- 3 destroyers capsized and sank, and 790 lives were lost
- 9 other warships were damaged, and over 100 aircraft were wrecked or washed overboard

1 May 1959: JTWC established by PACFLT/PACAF in Guam

1 Jan 1999: JTWC relocated to Pearl Harbor, HI due to BRAC





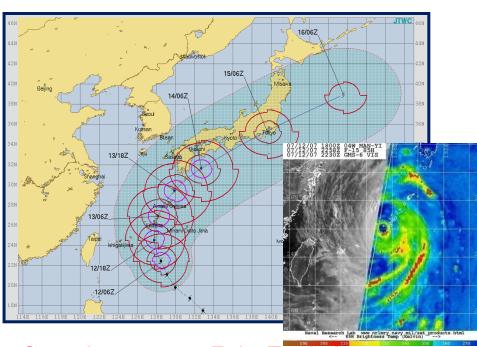
Command Mission





- Provide tropical cyclone reconnaissance, forecasting, and warning support for the Department of Defense and other U.S. Government agencies in the Pacific and Indian Oceans as established by Commander, United States Pacific Command.
- Provide tsunami decision support to U.S. Navy shore installations and fleet assets as directed by Commander, Fleet Forces Command.





Airmen from the 18th Aircraft Maintenance Squadron tow an F-15 Eagle into a protective aircraft shelter in preparation for Typhoon Man-Yi 12 Jul 07 at Kadena Air Base, Japan. (Source: U.S. Air Force/A1C Kasey Zickmund)

Naval Oceanography

Observe-Predict → Fight-Win

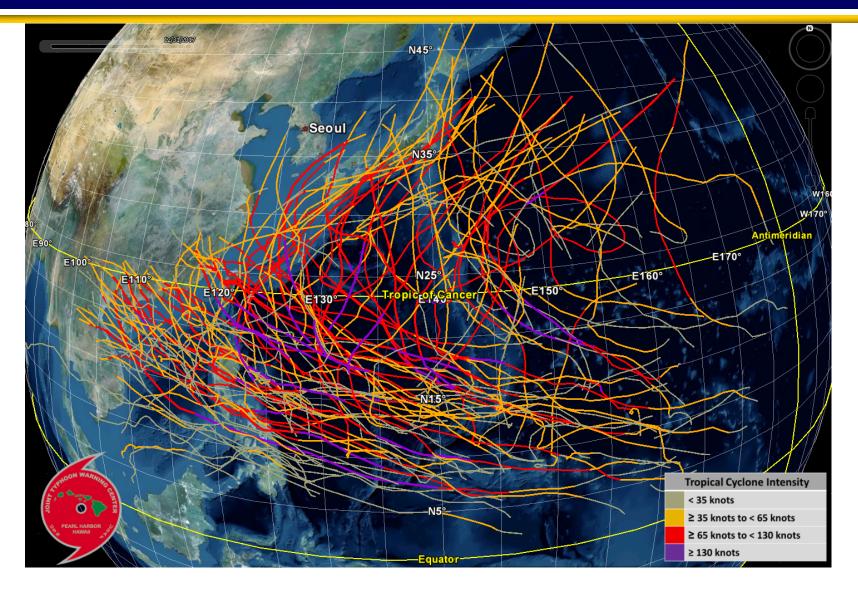


The Threat





Western North Pacific Tropical Cyclone Tracks (2013 – 2018)

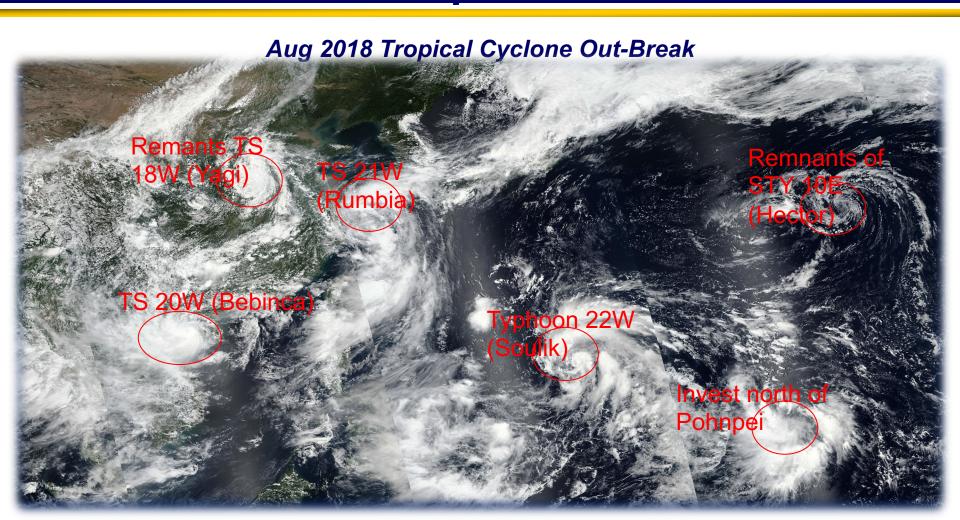




Joint Typhoon Warning Center Perspective





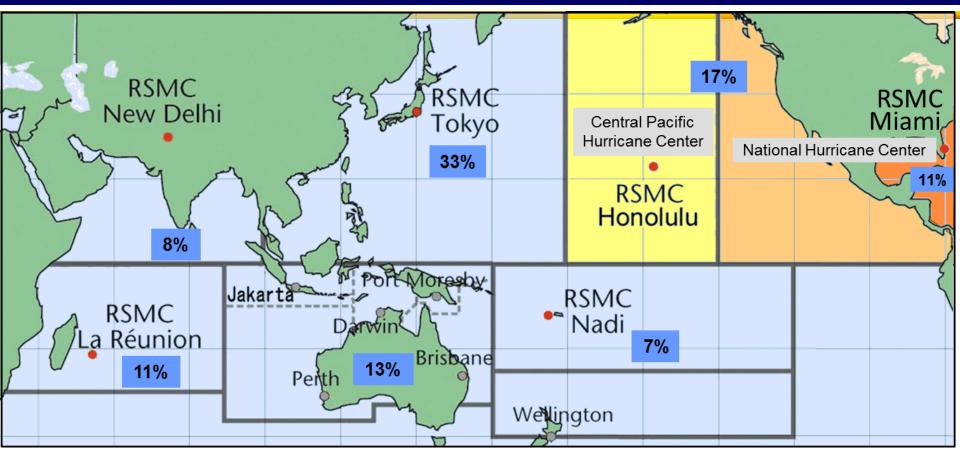




JTWC Tropical Cyclone Forecasting Area of Responsibility







- JTWC issues forecasts & warnings for blue shaded areas for use by DoD and other U.S. Government agencies.
- JTWC coordinates with CPHC & NHC regarding tropical cyclone forecasts in the eastern & central Pacific to ensure safety of DoD assets, but retains responsibility to issue DoD forecast if CPHC/NHC do not.



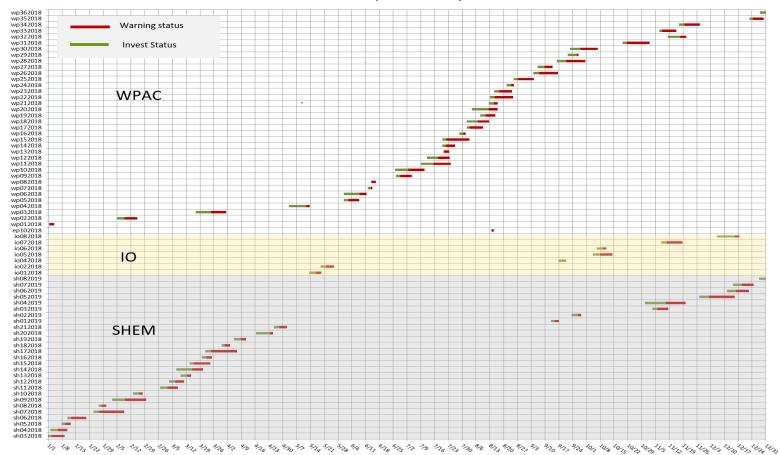
2018 calendar year





72 TCs 1,476 warnings

2018 JTWC Tropical Activity Timeline



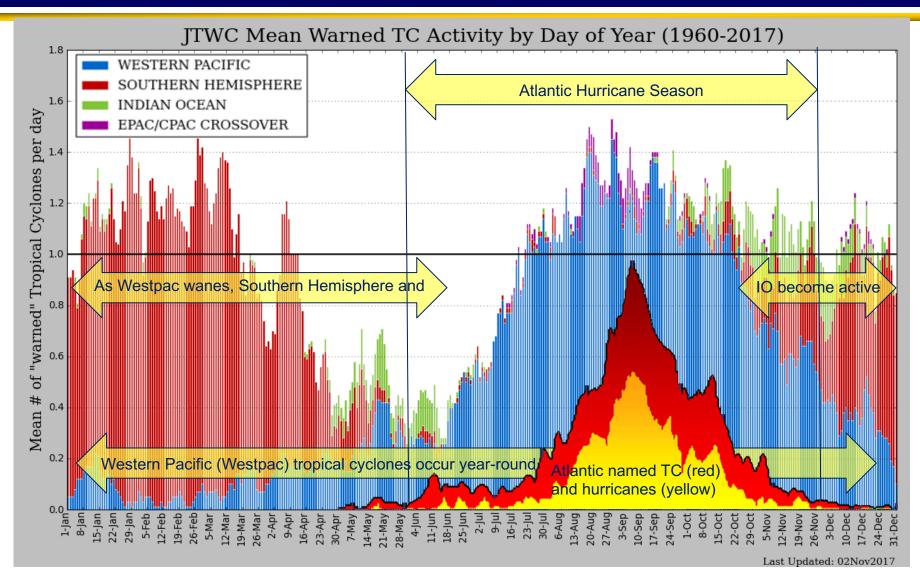
^{*} Does not include 261 Invests that DND (Did Not Develop)



Always Busy









Sat Retrieval- Mark IVb





- AF System- Lockheed Martin Hardware/Software
 - Display, enhance, manipulate and interrogate both geostationary and polar-orbiting satellite data.
- Ground stations-

Kapaun AS, Germany	MET PRIME (p)	MET IODC (p)	MET RSS (p)	GOES IO
Ali Al Salem AB, Kuwait	MET PRIME (s)	MET IODC (s)	MET-RSS (s)	
Kadena AB, Japan	GK-2A (p)	GOES IO		
Andersen AFB, Guam	HIMAWARI-8 (s)	GK-2A (s)		
Hickam AFB, Hawaii	HIMAWARI-8 (p)	GOES-WEST (s)		
Elmendorf AFB, Alaska	GOES-WEST (p)			
Soto Cano AB, Honduras	Polar only			
Lajes AB, Portugal	GOES-E			
Offutt, Nebraska	GOES-E			



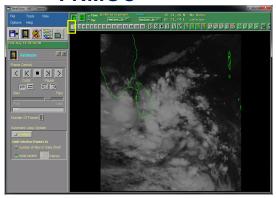
Sat Retrieval- FMQ-17

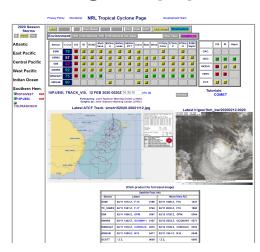
PARL MARCH

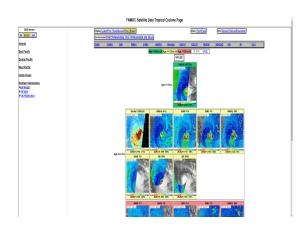


Navy Satellite Display System-Enhanced (NSDS-E)

- TeraScan (SeaSpace Corporation) The FMQ-17 hardware and TeraScan software enables analysts and forecasters to ingest, display, enhance, manipulate and interrogate both geostationary and polar-orbiting satellite data.
- Subcontracted by Raytheon, a contractor for SPAWAR (Navy).
- Ground Stations: Receive L-Band & S- Band (NOAA, DMSP, EUMETSAT)
- PH (GOES-W)
- NORFOLK (MET 8)
- NRL retrieves data for processing and population
 - NRL-TC page
 - FNMOC









Sat Retrieval- FNMOC & NRL

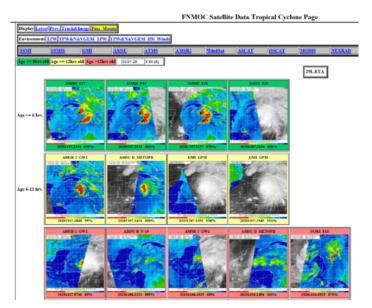


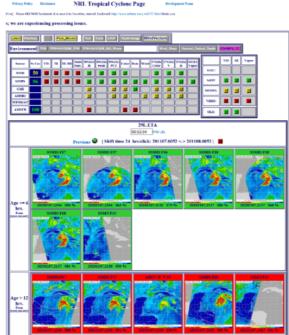


(Web page and ATCF inject)

Data availability

- Storm-centered geostationary and microwave imagery
 - Storm-centered imagery generally available within 1-3 hours of data capture time
 - Colored buttons/backgrounds indicate amount of time elapsed between current time and data capture time.
- · Imagery archives





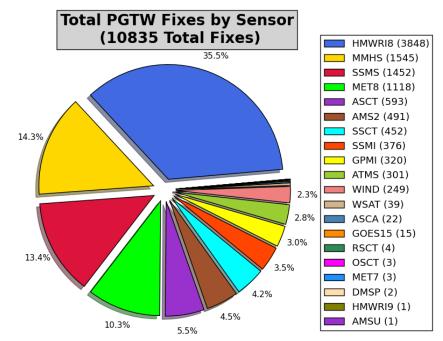


JTWC TC Recon Mission





- Team of 7 AF members (Cover 24/7)
- Exclusively remotely sensed data satellite/radar
 - Aircraft recon ended in 1987
- Infrared/Visible Imagery Fixes via Mark IVB every 3 hours—
 - Both Position & Intensity
- Microwave/scatterometer fixes as available—54% of total
- 35% Sounder derived





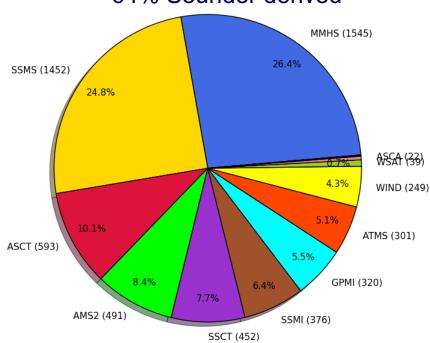
Satellite Fixes by Sensor (JTWC)





Microwave Fixes by Sensor (5848 Total Fixes)

64% Sounder derived

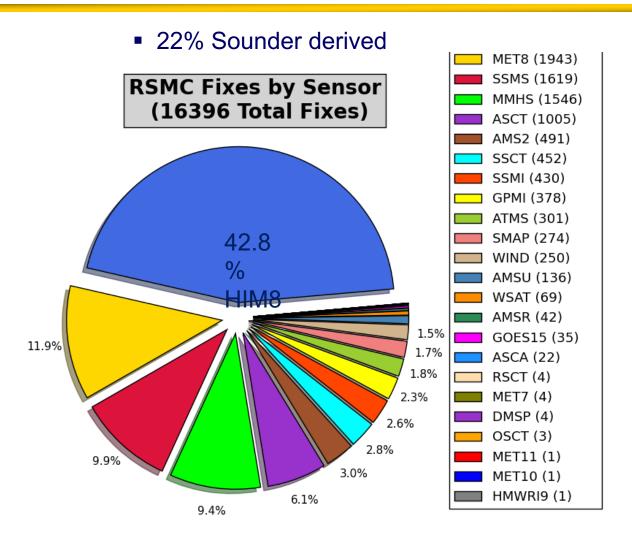




Regional Specialized Met Centers TC Recon









POES data use at JTWC





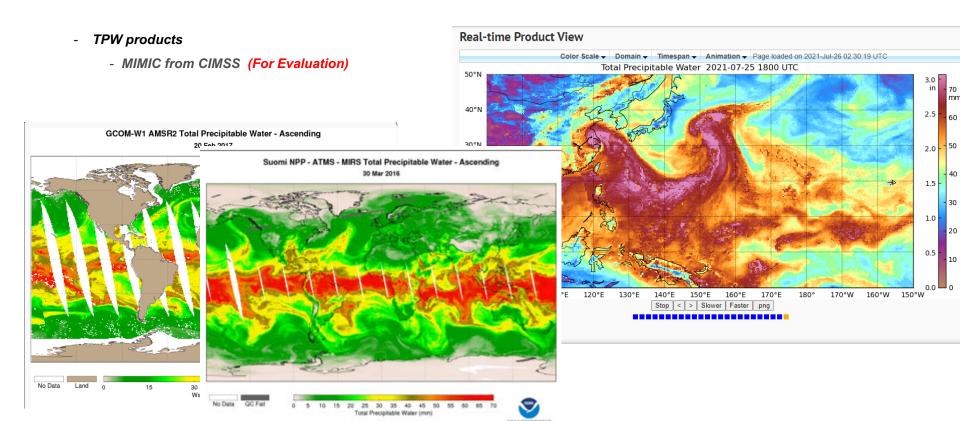
- Microwave Sounder: Analysis of TC internal structure
 - Intensity and wind radii estimation algorithms [AMSU /ATMS]
 - TPW products
 - Forecast model inject
- Microwave Imagery: Analysis of TC internal structure
 - Positional Fixes of LLCC
 - Recognition of potential Rapid Intensification event (Cyan Ring)
- Scatterometer: Analysis of wind field vectors and speed
 - Determination of closed circulations of nascent & developed TC
 - Wind radii determination of TC ≥34, ≥50, ≥64kts
- Altimeter: Wave height estimates for High Seas Advisories/Warnings(FWC-SD)
- Oceanic Heat Content (OHC): Data input into STIP/SHIPS model for intensity forecasting
- VIIRS Day Night Band: DNB used as available







- Sounder-derived imagery (mentioned previously)
 - Subjective Positional Fixes
 - Subjective AMSU cross-section Cyclone Phase determination
 - Objective Positional Fixes [ARCHER](For Evaluation)
 - <u>Objective Intensity</u> [CIMSS/CIRA AMSU &SATCON](For Evaluation)
 - Objective wind radii estimate algorithms [AMSU /ATMS] (For Evaluation)





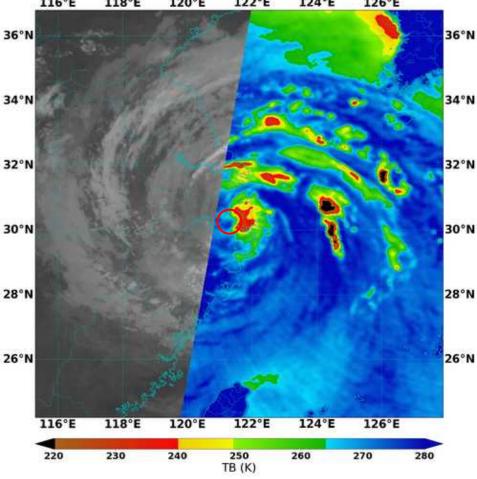




Subjective Positional Fixes- In addition to IR and





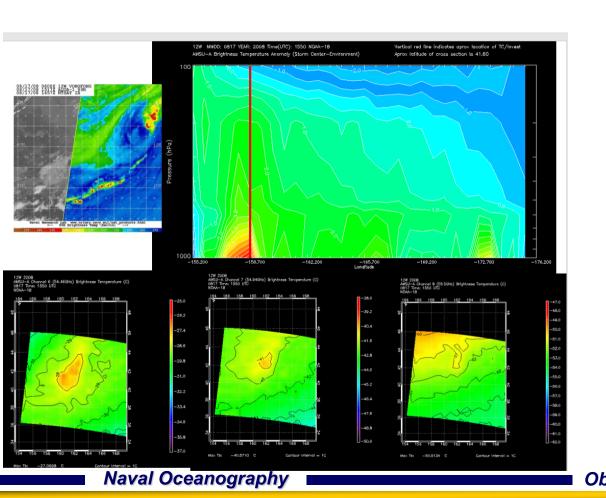


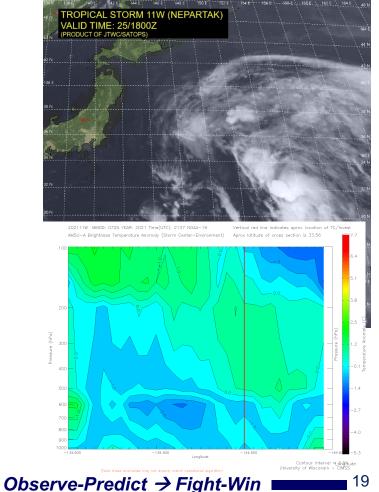






 Subjective Cyclone Phase determination using AMSU Brightness Temp cross-section











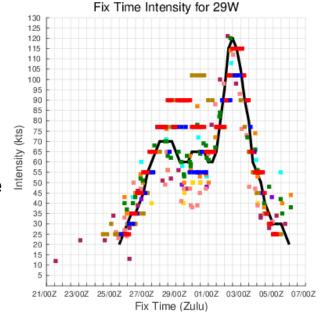
PGTW DVTS

Objective Intensity [CIMSS/CIRA AMSU &SATCON] (For Evaluation)

Advanced Microwave Sounding Unit (AMSU) - Based Intensity Estimates (CIMSS/CIRA/SSEC)

The Advanced Microwave Sounding Unit or AMSU, which is an instrument on the NOAA operational polar-orbiting satellites, has the capability to make temperature soundings. Using a combination of AMSU-based soundings, the hydrostatic relationship, and statistics, a tropical cyclone intensity estimate can be made.

A strong relationship exists between the brightness temperature anomalies as measured by the AMSU-A instrument and Tropical Cyclone (TC) intensity

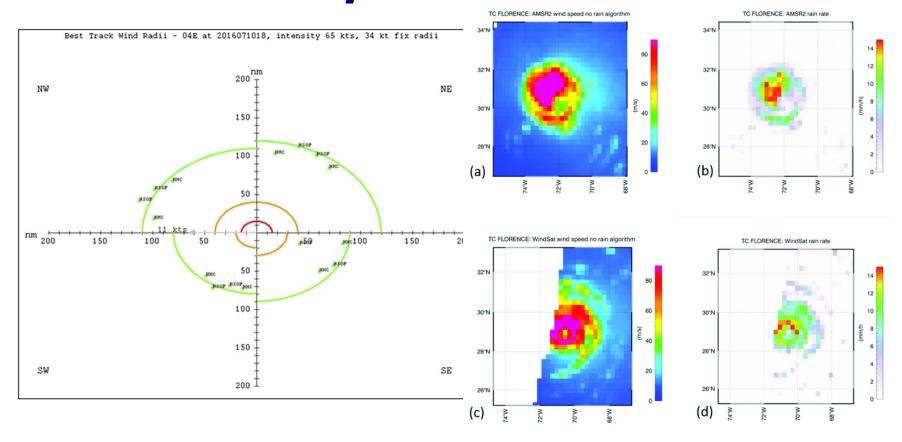








-Objective wind radii estimate algorithms [AMSU /ATMS/AMSR]





MW Imagery Value to TC Analysis





- Microwave Imagery from low earth orbiting (LEO) satellites is used in tropical cyclone analysis.
 Various frequencies can provide unique information about the location and organization of convective structures
- Structure and circulation can be obscured by high clouds in Infrared (IR) and water vapor (WV) imagery.
 - Cirrus canopies, which often cover tropical cyclones on visible and infrared images, are transparent at 85 GHz; thus, these images can the view the lower structure of the storms. For this reason, the SSM/I has been called the "poor man's radar"-McCrone

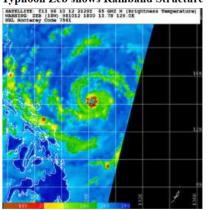


MW Imagery Value to TC Analysis

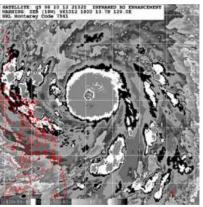






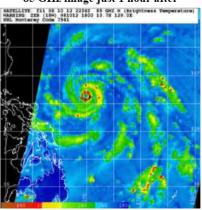


Infrared BD Enhancement shows

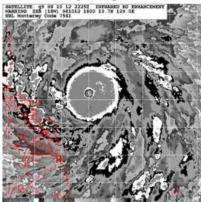


By October 12, Zeb has intensified, showing a closed eye in the image of 85 GHz H on the left. Deep convective spiral bands appear in greens and yellows with embedded reds. Land is quite "warm" at this frequency so that the Phillipines appear dark blue. Notice that the eye wall is a narrow ring of red, indicating the most intense convection. Notice that on the accompanying infrared image (right) this inner convection can not be observed.

85 GHz image just 1 hour after



Corresponding Infrared



The 85 GHz image on the left, imaged by DMSP F11, occurred only one hour after the previous pass by F13. This allows the opportunity for structural changes to occur on a short time table. Notice, for example, the strengthening of a secondary convective ring (yellow) just outside the eyewall (red), especially on the southern and eastern portion of the storm.

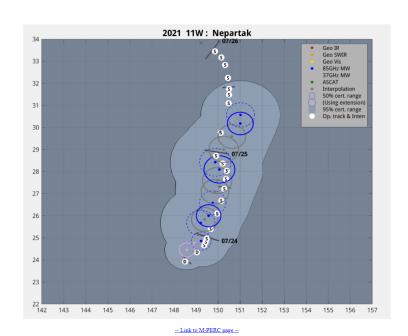


MW Imager Value to TC Analysis

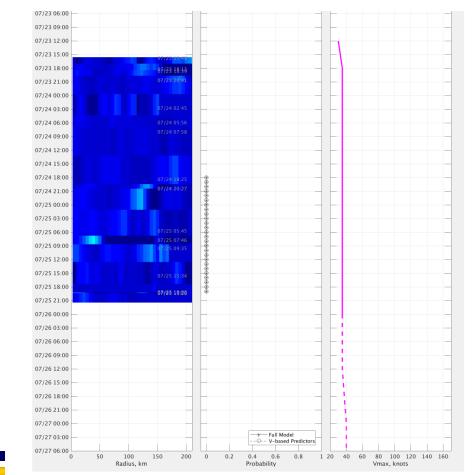




- Objective Positional Fixes [ARCHER](For Evaluation)
- Objective Eyewall Replacement[MPERC](For Evaluation)



Geo IR	85-92GHz	Date/Time_(UTC)	Source	Sensor	Vmax(kts)	ARCHER Lat	Lon	Geo-ref Lat	Lon	50% cert. rad.	95% cert. rad.	Eye diam (deg)
R		20210725 19:26:14 20210725 19:20:18 20210725 19:20:18 20210725 19:08:45	SSMIS-18 GMI GMI SSMI-15	85-92GHz 85-92GHz 37GHz 85-92GHz	35.0 35.0 35.0 35.0	***	***	***	***		***	3.00 0.20 0.90 3.00
B	M	20210725 15:34:08 20210725 15:34:08	AMSR2 AMSR2	85-92GHz 37GHz	35.0 35.0	***	***	***	***	***	***	0.50 3.00



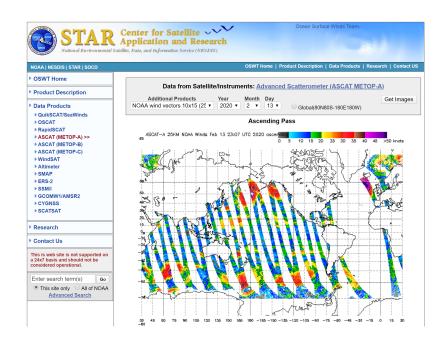


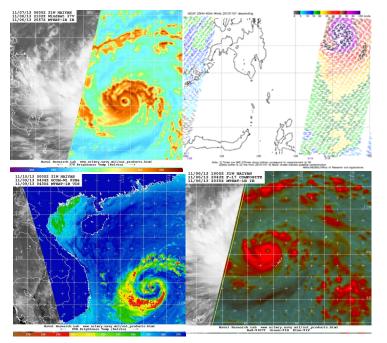
Scatterometer Value to TC Analysis





- STAR/ NESDIS web pages and NRL/FNMOC for access to SCAT
 - ASCAT is the highest confidence intensity and position data available









- JTWC Analysts utilize subjective techniques
 - IR and VIS-Dvorak Techniques for Position and Intensity
 - Microwave-Position only
 - SMAP/SAR

For Example: OSCAT- perfectly symmetrical wind radaii/structure due to ECMWF model field input (No ambiguities available)

- Used with a grain of salt-due to outside influences (NWP) rather than pure "ground truth" data
- ADT/SatCon evaluation-exception
 - CIMSS-

extensive training and input knowledge



VIS & IR Imagery Value to TC **Analysis**





 IR and WV imagery, which are available from geostationary satellites, have also been routinely used to monitor the organization, location, and intensity of TCs and infer changes in the TCs near environment. In the operational setting these three types of satellite imagery are typically viewed and analyzed separately (i.e., individual PMI images, and loops of WV and IR imagery)



2D Winds

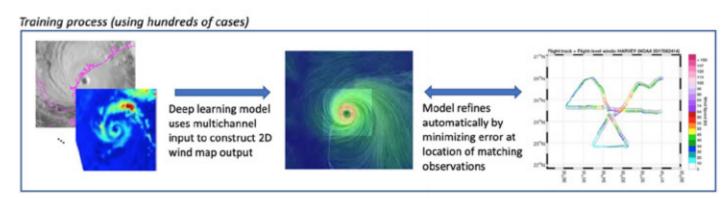


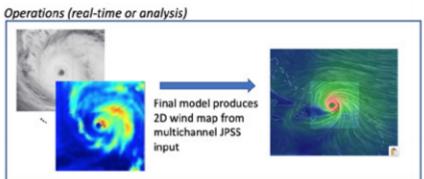


Two-Dimensional Tropical Cyclone Winds (For Evaluation)

CIMSS Upcoming: Using Deep Learning to construct a 2D TC wind field

- Our 2021-2024 research
 effort will use deep
 learning to associate
 ATMS and VIIRS
 imagery to twodimensional TC surface
 wind fields
- The motivation is that satellite imagery has uniquely detailed depictions of TC structures, and deep learning can be used to relate this to elusive inner-core wind patterns





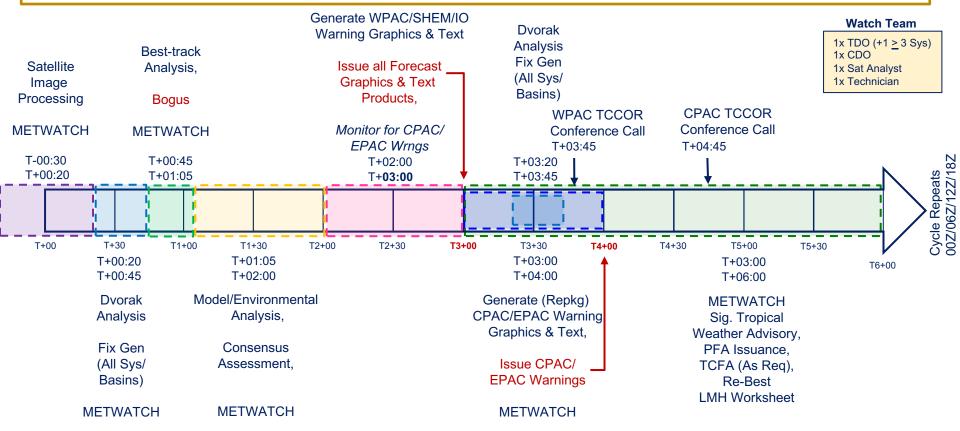


JTWC Watch Timeline





The JTWC AOR requires constant monitoring of over 110 million sq. miles. With nearly 1,000 annual mean warnings, tight integration of optimized automated tropical cyclone forecast system (i.e., ATCF) and highly trained and educated personnel is critical to maintain a strict 3-hour production cycle.



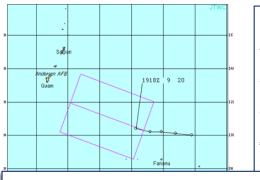


Tropical Cyclone Forecasting





Enable effective Fleet and Joint Force operations and planning through tropical cyclone reconnaissance, forecast, warning, and decision support to U.S. assets in the Pacific and Indian Oceans as established by Commander, U.S. Pacific Command.

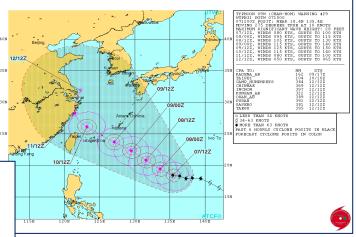


MSGID/GENADMIN/NAVMARFCSTCEN PEARL HARBOR HI/JTWC// SUBJ/SIGNIFICANT TROPICAL WEATHER ADVISORY FOR THE WESTERN AND /SOUTH PACIFIC OCEANS/2206002-2306002JUL2011/ REF/A/MSG/NAVMARFCSTCEN PEARL HARBOR HI/220151ZJUL2011/ AMPN/REF A IS A TROPICAL CYCLONE WARNING.//

- 1. WESTERN NORTH PACIFIC AREA (180 TO MALAY PENINSULA): A. TROPICAL CYCLONE SUMMARY:
- (1) AT 220000Z, TROPICAL DEPRESSION 08W (MA-ON) WAS LOCATED NEAR 28.9N 142.7E, APPROXIMATELY 435 NM SOUTH-SOUTHEAST OF TOKYO, JAPAN, AND HAD TRACKED SOUTHEASTWARD AT 11 KNOTS DURING THE PAST SIX HOURS. MAXIMUM SUSTAINED SURFACE WINDS WERE ESTIMATED AT 20 KNOTS GUSTING TO 30 KNOTS. SEE REF A (WTPN31 PGTW 220300) FOR THE FINAL WARNING ON THIS SYSTEM.
 - (2) NO OTHER TROPICAL CYCLONES
 - B. TROPICAL DISTURBANCE SUMMARY:

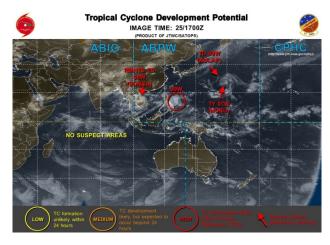
APPROXIMATELY 265 NM EAST OF CEBU, PHILIPPINES, AND IS SHOWING POTENTIAL FOR DEVELOPMENT OVER THE LONG TERM. THE LOW LEVEL CIRCULATION CENTER (LLCC) IS CURRENTLY POORLY DEFINED ON ANIMATED SATELLITE IMAGERY. BUT THE 220000Z PGTW STREAMLINE ANALYSIS REVEALS THE MONSOON TROUGH IS RAPIDLY BECOMING RE-ESTABLISHED OVER THE CONVECTION ON THE SOUTH SIDE OF THE TROUGH. A 212327Z SSMIS IMAGE AND DEEPENING CONVECTION ON THE SOUTHERN SIDE. MAXIMUM SUSTAINED SURFACE WINDS ARE ESTIMATED AT 10 TO 15 KNOTS. MINIMUM SEA LEVEL PRESSURE IS ESTIMATED TO BE NEAR 1008 MB. THE POTENTIAL FOR THE DEVELOPMENT OF A SIGNIFICANT TROPICAL CYCLONE WITHIN THE NEXT 24

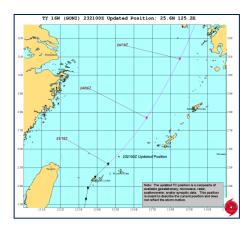
- (2) NO OTHER SUSPECT AREAS
- 2. SOUTH PACIFIC AREA (WEST COAST OF SOUTH AMERICA TO 135 EAST):
- A. TROPICAL CYCLONE SUMMARY: NONE. B. TROPICAL DISTURBANCE SUMMARY: NONE.//



TC Forecast Products

- Daily Significant Tropical Weather **Advisories**
- **Tropical Cyclone Formation Alerts** (TCFA)
- TC Warning Packages
 - Warning message/graphics
 - Prognostic reasoning message





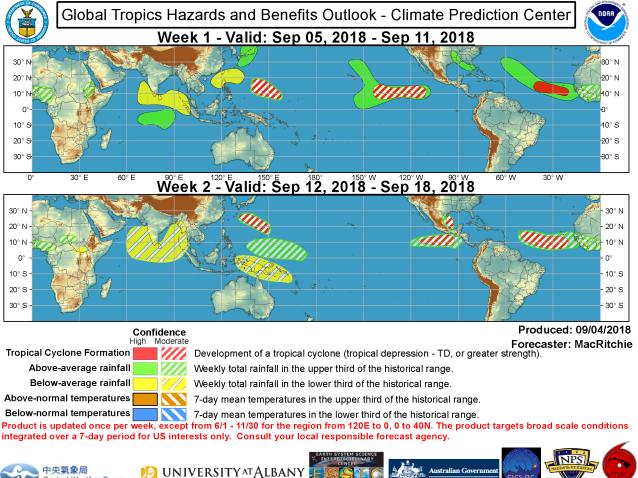


Interagency Collaboration: Global Tropical Hazards/Benefits





Actively identify potential TC formation areas during weekly Global Tropical Hazards/Benefits Outlook teleconference with Climate Prediction Center















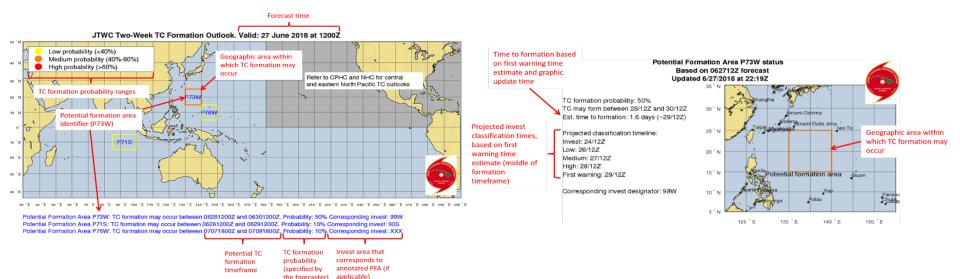


Process Development & Transition: Two-week Outlooks





- Operational process developed by Tech Services to 1) provide advanced situational awareness to DoD customers, 2) improve 24-hour TC formation potential classifications and 3) increase first forecast accuracy
 - JTWC began issuing twice-daily two-week TC formation outlooks to DoD customers 01 July 2018; added into Collaboration website (https://pzal.metoc.navy.mil/) December 2019
 - Specify locations/times at which TC formation favored by anticipated environmental conditions and model forecasts during two-week period
 - Increased mean TC formation notification lead time from approx. 2.2 days to approx. 5.5 days
 - Two-week outlooks consist of an AOR-scale graphic and detail graphics for each identified potential formation area (examples below)





Multi-Agency Collaboration

































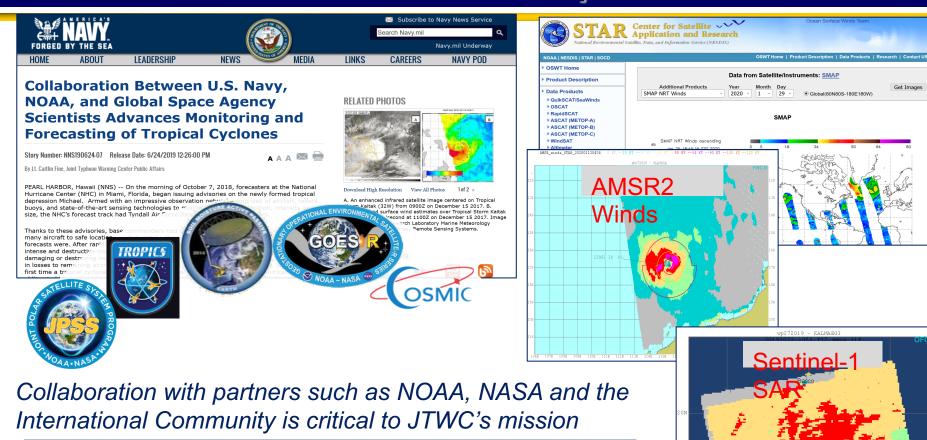




Space-Based Sensing Partnership







The design and launch of new sensors, data processing, and development of advanced techniques developed by NESDIS, the Cooperative Institutes, and many other partners supports remote sensing of nearly 75% of global tropical activity without routine aerial reconnaissance.



NOAA/NWS – JTWC Partnerships





- Joint Hurricane Testbed Steering Committee
- Hurricane Forecast Improvement Program Data sharing
- NOAA NESDIS Global TC "fixing"
- NOAA NESDIS Satellite requirements / techniques development
- NOAA Satellite Operations Facility Data exchange / product generation
- Climate Prediction Center Global Tropics Hazards
- National Hurricane Center Long standing ATCF CO-OP
- AWIPS II DoD/DoC seeking accreditation reciprocity
- NWS Pacific Region NOAAPORT feed and AWIPS collaboration
- Central Pacific Hurricane Center TC fixes for CPHC area of responsibility
- WFO Guam / WSO Pago Pago Direct support for TCs including "hotline"
- National Climatic Data Center IBTrACS contributor
- Indo-Pacific Meteorological Group (IPMG) Pacific Region Rep
- Interdepartmental Hurricane Conference Routine attendance/contributions

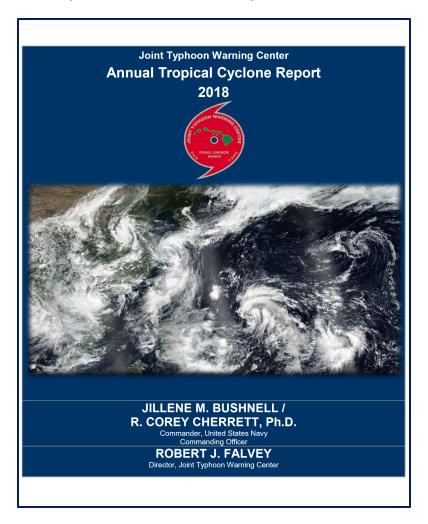


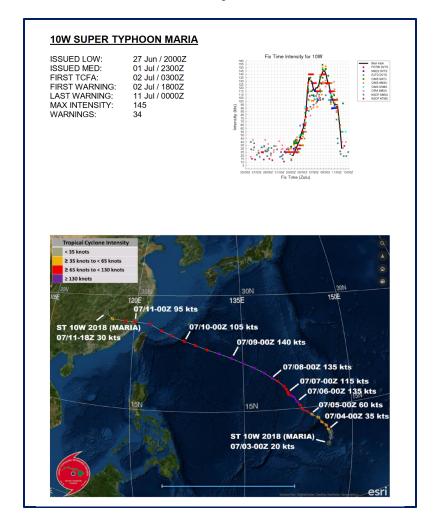
Annual Tropical Cyclone Report





Compile and edit comprehensive review of annual TC activity





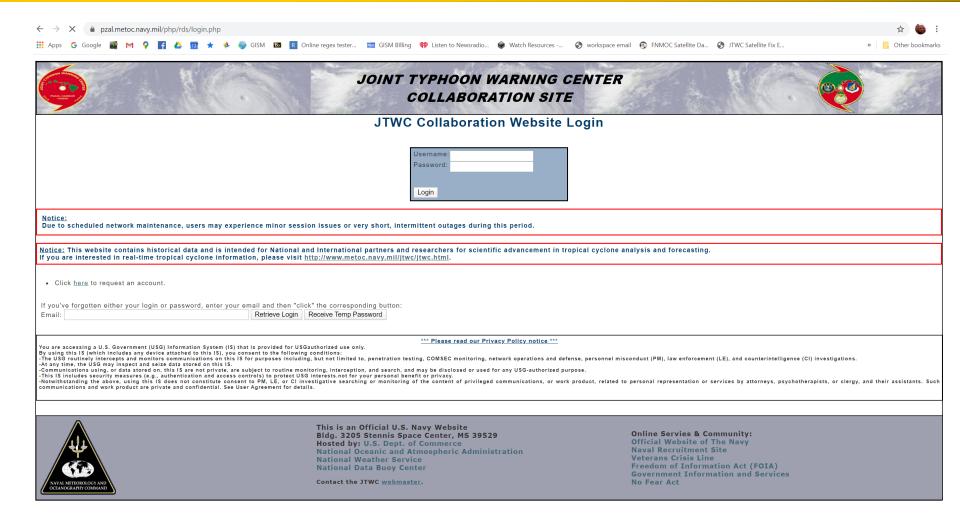




Collaboration Site









Conclusion





With diminishing POES platforms/data available JTWC is excited for new LEO platforms to come on-line

Data should not be "black box" generated- JTWC Forecasters will receive training on new technology and understand the variables that make up a new resource

Data latency is important: Data must be in the hands of the analyst/forecaster < 6 hrs <3hrs is highly desirable.

Development of subjective analysis of microwave imagery for TC intensity must continue Development of techniques using new higher frequency data must begin

Questions?